ESR Studies of Magnetic Semiconductors

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1. Introduction

Electron spin resonance is a powerful means to discuss about the local structure at the spin site, the spin dynamics and the internal field. As examples, two ESR studies on GaAs:Er,O [1,2] and GdN [3] will be discussed. [1].

ESR studies on GaAs:Er,O without carriers at low temperature showed three ESR signals A, B and C which suggest the existence of Er-2O centers with slightly different local structures [1,2]. The ESR intensity is strongest at around 8 K and decreases below 8 K suggesting the existence of antiferromagnetic exchange interaction.

ESR study of GdN clearly showed the ferromagnetic resonance (FMR) at 4.2 K judging from the angular dependence. Moreover, it showed two shifts of FMR below 70 K and 36 K while ferromagnetic transition temperature T_c was determined to be 36 K from the Alott plot [3].

Our extended ESR studies of GaAs;Er,O and GdN will be discussed.

2. Experimental Approach and Results

ESR measurement can performed from T= 4.7K to 300K using Bruker ESR spectrometer EMX081 with TE103 rectangular cavity and Oxford He-flow cryostat ESR 900 at Kobe University. The frequency of microwave is about 9.5 GHz and external magnetic field can be swept up to 9000G.

We have studied three different epitaxial films of GaAs;Er,O with carriers. GA040396 showed n-type with charge carrier 5.6x1014 cm^{-3}, GA050462 showed high resistance and GA050461 showed p-type with hole concentration 5.7x1016 cm^{-3}.The Er con-centration in GA040396, GA050462, GA050461 were es-timated to be 7.0x1017, 4.0x1018, 1.0x1019 cm^{-3} respectively by SIMS. The angular dependence of g-values for A, B and C centers showed similar behaviors with previous results [1] suggesting that the local structures of Er-2O center are similar. The line shape analyses showed the tendency to become Lorentzian line shape as the Er concentration increased suggesting the exsistence of exchange interaction. The temperature dependence of ESR intensity showed similar behavior to previous results [1,2].

Detailed analyses of temperature dependence of ESR for GdN showed the in crease of linewidth above 70 K while the linewidth should be constant down to T_c for typical ferromagnet. The FMR analyses based on the molecular field theory will be also discussed.

3. Conclusions

In summary, we have shown our extended ESR studies of GaAs;Er,O and GdN. Although there are some open questions, I hope I was able to show that ESR studies of magnetic semiconductors are rather useful.

4. Open Questions

Open questions to be discussed are the followings.

- Connection between the PL mechanism and the observed ESR signals B and C in GaAs:Er,O?
- Is it really reasonable to consider the antiferromagnetic exchange interaction between B and C centers?
- What is the origin of linewidth for the observed ESR signals B and C in GaAs:Er,O? It is difficult to interpret only by the magnetic dipole-dipole interaction.
- The origin of temperature dependence observed in the linewidth of GdN?
- The origin of two FMR signals observed below 70 K in GdN?

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